

Computation of the spectra of the quasars.

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Abstract

The repartition of redshifts of the lines observed in the spectra of the quasars is generally considered as stochastic, but several authors showed that the difference of two redshifts is the product of an integer by a basic redshift $z_f = 0.062$. This property results from a coherent Raman effect during the propagation of the incoherent light in a halo of atomic hydrogen, without any jet of gas, or dark matter. The coherence forbids a blur of the images or of the spectra. The computation of z_f does not require any new spectroscopic parameter. The non-linearity of the combination of Lyman absorptions and coherent Raman effect explains both the observed positions of the spectral lines and their high contrast.

1 Introduction

The credibility of the standard explanations of the spectra of the quasars appears low: The Lyman lines of the atomic hydrogen appear with a lot of different redshifts generally considered as produced by a Doppler effect or by an expansion of the Universe. Both hypothesis have flaws because they require clouds of hot atomic hydrogen whose speed or stability cannot be explained using regular physics.

Studying the propagation of light in low pressure gases, one must take into account the “Coherent Raman Effect on time-Incoherent Light” (CREIL) which transfers energy by frequency shifts from the hot modes of light to the thermal modes without any blur of the images and of the spectra; the relative frequency shifts $\Delta\nu/\nu$ due to CREIL are nearly constant.

In a previous paper [1], we explained that the spectra can be obtained assuming that a nearly homogeneous cloud of Lyman pumped, atomic hydrogen is perturbed by a variable magnetic field: where the field is very low, there is nearly no redshift, the absorption (or emission) lines are written visibly into the spectrum; else, the redshift simultaneous with

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absorption (or emission) blurs the lines which become invisible. The spectrum results not from a modulation of the absorption, but from a modulation of the redshifting power of the gas. We showed the existence of a non-linearity able to increase the contrast of the lines.

However our previous explanation requires an important variation of the magnetic field for each line, thus, the existence of a large number of magnetised satellites. Worse, the spectra show a pseudo-stochastic repartition of the redshifts of the lines, the difference of two redshifts being the product of a constant $z_f = 0.062$ by an integer [2, 3, 4, 5]. It seems very difficult to explain such a spectroscopic regularity of the “intrinsic redshift” by the presence of objects on the line of sight; the non-linearity we had introduced provides a very simple solution.

Section 2 reminds the key spectroscopic property which provides the intrinsic redshifts, the “Coherent Raman Effect on time-Incoherent Light”(CREIL) which is an avatar of the well known “Impulsive Stimulated Raman Scattering”(ISRS).

Section 3 applies the CREIL to a halo of atomic hydrogen; to get the required resonances, H must have a non-zero orbital quantum number, so that the necessary Lyman pumping introduces a non-linearity.

2 The “Coherent Raman Effect on time-Incoherent Light” as a limit case of the “Impulsive Stimulated Raman Scattering”.

The “Impulsive Stimulated Raman Scattering”(ISRS) was discovered in 1968 [6] and is commonly used to study the matter [7, 8, 9, 10]. ISRS is a light-matter interaction which transfers energy from a pulsed laser beam to a colder pulsed laser beam, by frequency shifts of the beams, the temperature of the beams being deduced from Planck’s law. ISRS is space-coherent, that is the wave surfaces are left unchanged. ISRS is a parametric effect which uses matter as a catalyst, leaving it unchanged; it may be considered as a combination of two nearly simultaneous Raman scatterings giving virtual, opposite transitions. The relaxation times of the matter used as a catalyst must be longer than the length of the light pulses; these relaxation times are the period of (at least) a Raman-allowed transition, and, in a gas, the collisional time.

Replacing the ultrashort, powerful pulses of lasers by the pulses which make the ordinary incoherent light is a large change of the power and of the length of the pulses [11, 12, 13].

The change of power has a qualitative effect: In ISRS, the Raman scattered amplitude which, by interference with the exciting amplitude, produces the frequency shifts, is an increasing function, nearly quadratic, of the exciting amplitude. At low power, all scatterings are linear: If the coherence is broken by frequent collisions (ordinary Raman), the scattered intensity is proportional to the exciting intensity; else the coherently scattered amplitude is proportional to the exciting amplitude (Refraction, that is coherent Rayleigh scattering, Bragg scattering, coherent Raman

scattering and photon echoes in microwaves...). This behaviour which makes the frequency shifts independent on the intensities justifies a different name: "Coherent Raman Effect on time-Incoherent Light"(CREIL). ISRS and CREIL may be computed from the tensors of polarisability of the molecules which do not depend much on the exciting frequencies, so that, in a first approximation, the relative frequency shift $\Delta\nu/\nu$ does not depend on the exciting frequency ν .

As the length of the pulses, of the order of 5 nanoseconds, is larger than using lasers, the collisional time must be longer than 5 ns, so that the pressure must be lower than some Pascals. The Raman resonance period must be longer than 5 ns too, so that, to be active in CREIL, the molecules must have Raman resonances in the MHz range. Both conditions decrease the intensity of the frequency shift : therefore its observation requires a very long path which is not available in an usual laboratory.

In astrophysics, the thermal radiation, at least the 2.7K radiation, provides low temperature exciting beams whose blueshift corresponds to an amplification or a heating; the required long path is evidently available; it remains finding molecules having convenient Raman resonances. As hydrogen is the most common gas, two molecules may be considered:

- H_2^+ has Raman resonances close to 30 MHz, but it has probably not been observed although it should be produced by an ionisation of H_2 by the ultraviolet radiation. The reason is very simple: as H_2^+ is destroyed by the collisions with H_2 , its life-time is long only where the pressure is low enough to allow CREIL. A simultaneous absorption and CREIL makes absorption lines as wide as the redshift; therefore the almost forbidden lines of H_2^+ are so wide and weak that they cannot be seen.

- atomic hydrogen may have convenient transitions if it has been pumped by a Lyman transition so that hyperfine structures producing two photons resonances in the MHz range appear.

3 Propagation of light in atomic hydrogen.

Consider the propagation of light having a continuous spectrum (constant intensity I , in particular in the Lyman region), in an homogeneous atmosphere of low pressure atomic hydrogen. In the fundamental state (principal quantum number $n=1$), the distance between the hyperfine levels (1420 MHz) is too large. In the other states, hyperfine transitions have convenient frequencies for the Raman allowed selection rule $\Delta F = 1$, for instance : 178 MHz in $2s_{1/2}$, 59 MHz in $2p_{1/2}$ and 24 MHz in $2p_{3/2}$.

Set ΔL the length of path for which the redshift is equal to the linewidth $\delta\nu$ of the Lyman α line, and assume that the atoms which are active in CREIL are mostly pumped by the Lyman α transition.

Set $\Delta\nu$ the redshift along the path ΔL , which *would* result from a *complete* Lyman α absorption of the intensity I , and suppose that, in a first approximation, the whole redshift results from the Lyman α absorption.

- case a: If $\Delta\nu$ is larger than the Lyman α linewidth $\delta\nu$, that is if I is large enough, I is not fully absorbed, only the *constant* intensity ΔI which

produces the redshift $\delta\nu$ is subtracted from I , that is from the spectrum while, by the redshift, the Lyman line crosses it. Thus, the contrast of lines which have been written into the spectrum is increased.

- case b: If, on the contrary, $\Delta\nu$ is lower than $\delta\nu$, the first approximation fails, a part of the redshift must result from other Lyman absorptions or other active atoms. Assuming a low redshifting power for these effects, a long path ΔL is necessary to get the redshift $\delta\nu$, so that the absorption of all lines is strong.

If the intensity I is constant and high, except for a single absorption line, the redshift and the absorption are constant (case a), except at a coincidence of the line with a Lyman line; at this coincidence, the redshifting power decreases (strongly if case b is reached), so that the absorption of **all lines** of the gas is increased; similarly, a written emission line increases the redshifting power, so that the decrease of absorption appears as an emission; *the coincidence by redshift of a line already written in the spectrum with a Lyman line writes the whole spectral pattern of the gas into the spectrum.*

4 The “forest” is made of “trees”.

Suppose that a single Lyman pattern is written in the spectrum. The coincidence of the written, redshifted Lyman β (resp. Lyman γ) line with the Lyman α line of the gas writes the Lyman pattern into the gas. Both patterns differ by the shift of frequencies $\nu_{(\beta \text{ resp. } \gamma)} - \nu_\alpha$ of the α and β (resp. γ) lines. As in the standard computations the lines are considered as Lyman α , the frequency shift is relative to the Lyman α frequency:

$$z_{(\beta \text{ resp. } \gamma), \alpha} = \frac{\nu_{(\beta \text{ resp. } \gamma)} - \nu_\alpha}{\nu_\alpha} \approx \frac{1 - 1/(3^2 \text{ resp. } 4^2) - (1 - 1/2^2)}{1 - 1/2^2} \quad (1)$$

$$z_{(\beta, \alpha)} \approx 5/27 \approx 0.1852 \approx 3 * 0.0617; z_{(\gamma, \alpha)} = 1/4 = 0.25 = 4 * 0.0625. \quad (2)$$

Similarly $z_{(\gamma, \beta)} \approx 7/108 \approx 0.065$. The redshifts appear, with a good approximation as the products of $z_f = 0.062$ by an integer q .

The intensities of the Lyman lines are decreasing functions of the final principal quantum number n , so that the inscription of a pattern is better for $q = 3$ than for $q = 4$ and *a fortiori* for $q = 1$.

Iterating, the coincidences of the shifted lines frequencies with the Lyman β or α frequencies build a tree, final values of q being sums of the basic values 4, 3 and 1. Each step being characterised by the value of q , a generation of successive lines is characterised by successive values of $q : q_1, q_2 \dots$. As the final redshift is $q_F * z_f = (q_1 + q_2 + \dots) * z_f$, the addition $q_F = q_1 + q_2 + \dots$ is both a symbolic representation of the successive elementary processes, and the result of these processes.

The name “tree” is not very good because branches of the tree may be stuck by coincidences of frequencies. A remarkable coincidence happens for $q = 10$, this number being obtained by the effective coincidences deduced from:

$$10 = 3 + 3 + 4 = 3 + 4 + 3 = 4 + 3 + 3 = 3 + 3 + 3 + 1 = \dots \quad (3)$$

$q = 10$ is so remarkable that $z = 0.62$ may seem experimentally a value of z more fundamental than z_f . In these computations, the levels for a value of the principal quantum number n larger than 4 are not taken into account, assuming that the corresponding transitions are too weak.

Is the forest made of a single or several trees?

5 Conclusion

The present computation is a quantitative explanation of the frequencies observed in the spectra of the quasars. It requires only elementary physics, no unknown matter. The computation should be improved by an evaluation of the intensities.

The CREIL appears as a key in the study of the quasars. It should probably be helpful for other studies: for instance, some astrophysicists think that the dark matter needed to get the gravitational stability could be simply molecular hydrogen; if this is true, it exists some H_2^+ , and a contribution of the CREIL not only to the “intrinsic” redshifts, but to the “cosmological” redshift.

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